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54 Display device.

57 Television receiver 1 of Figure 1 has a liquid crystal display 2 formed of a lattice of display elements 3 made from liquid crystal material, each element being individually acutable, the lattice of elements 3 being backlit by fluorescent tubes 4 whose light intensity and duration of operation can be controlled. The video signal has a 70Hz scan rate and a scan period of 14mS, each picture of display information having an 8-bit word for each display element, a word beginning with the most-significant-bit and ending with the least-significant-bit.

In the processing for the display of the most-significant-bits of the words, frame store 6 outputs the first bit of each word and sends the bits to a control unit 7 for an array of drivers 8, one being assigned to each row and column of the lattice for setting of each element to its appropriate condition. Once all the elements are set, driver control unit 7 activates the tubes 4 for a time duration and intensity appropriate to the significance of the bit.

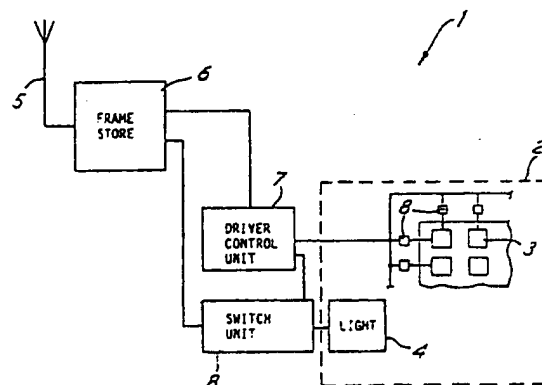


Fig.1

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## DISPLAY DEVICE

The present invention relates to a display device, and particularly but not solely to one which utilizes liquid crystal display elements.

A conventional liquid crystal display has a lattice of liquid crystal display elements each with its own driver and storage capacity to enable activation independently of the other elements. The on/off period of each element can be modulated in order to provide a number of intensity levels of display at that element.

The present invention provides a display device to provide a grey-scale display, the device comprising:

a lattice of bi-stable display elements;  
means to input a signal representing the display information for one picture to a store;  
means to output, from the store, the display information for one picture in sections, each section consisting of corresponding portions of display information for all the bi-stable display elements;  
a plurality of drivers, each allocated to a row or column of the lattice, to set each display element to a condition in accordance with its respective portion of the signal from the output means;  
means to produce a light output; and  
means to modulate the light output in accordance with the significance of the signal from the output means.

In this way, the display device does not require a driver for each element, thereby providing a substantial simplification in the arrangement of constituent components of the device, and enabling multiplexed operation of the display device.

Preferably, the signal for one picture comprises a sequence of words (for example each of 8 bits), each one corresponding to the display information for a display element in the lattice. Thus the output means can operate such as to take out, from the store, the first bit in each word and pass them sequentially to the lattice; thereafter the output means can operate such as to take out, from the store, the second bit in each word and pass them sequentially to the lattice. This operation can be repeated until all the bits have been processed in this way.

As the bits in a given position (e.g. first) in the display word reach the drivers, they set each pixel to the corresponding condition. Once the entire lattice has been set in accordance with a given bit-position, the light-modulation means can be activated to output light in accordance with the given bit-position; thus, for example, if the given bit-position is the first bit in the word and this is designated as the most-significant bit, when the light output with the elements in this condition is

accordingly a substantial fraction of the total output. The light output for the most-significant-bit setting may be double that for the secondmost-significant-bit setting, which is itself double that for the third most-significant-bit setting, and so on. The light modulation means may have means to regulate the intensity of the light output in accordance with the given bit-position, and/or means to regulate the duration of light output in accordance with the given bit-position.

Preferably the display device may have means to blank the elements during setting of the elements for a given bit position.

For a colour display, preferably the display device has a lattice formed of groups of three display elements, each of the elements in a group producing a different colour and being set separately. In an alternative arrangement, the lattice is formed of a single display elements, each of which is exposed to light of the three colours sequentially, an element being re-set after each exposure.

The present invention also provides a method of operating a grey-scale display device having a lattice of bi-stable display elements, the method comprising:-

inputting a signal, representing the display information for one picture, to a store;  
outputting from the store a section of the display information for one picture, the section consisting of corresponding portions of display information for all the bi-stable display elements;  
using a plurality of drivers, each allocated to a row or column of the lattice, to effect setting of each display element to a condition in accordance with its respective portion of the signal from the output means;  
producing a light output, one the elements are set, modulated in accordance with the significance of the portion of the video signal;  
outputting from the store a second section of the display information, the second section consisting of different corresponding portions of display information for all the bi-stable display elements, and effecting the setting and modulating operations for the second section; and  
repeating the outputting, setting and modulating operations on any further corresponding portions.

Preferably, the signal comprises an 8-bit word for each element, and the most-significant-bit of each word is first output from the store for setting and display. Thereafter the second-most-significant-bit of each word is output from the store for setting and display, the total light output being half the previous output. This sequence is repeated until the least-significant bit has been displayed.

Preferably, modulation of the light output is achieved by regulation of the light intensity and/or of the duration of light output.

Preferably, each row and column of the lattice has a separate driver. Alternatively, each column has a separate driver, and some or all the rows have a common driver.

Preferably a display element comprises one or more selectively-settable liquid crystal cells.

The present invention is applicable to many forms of displays, for example to one in which the image is presented at a surface of liquid crystal panel backlit by fluorescent tubes, or to one in which the image is projected onto a screen by means of a liquid crystal panel positioned in the path of a light beam. Also, the present invention is applicable to colour displays and to black-and-white displays.

Furthermore, the present invention also embodies equipment for the generation, and/or transmission, and/or reception, and/or processing, of signals suited and/or designated for a display device as herein defined.

In order that the invention may more readily be understood, a description is now given, by way of example only, reference being made to the sole accompanying drawings in which:

Figure 1 is a block diagram of a display device embodying the present invention;

Figure 2 is another block diagram of a display device embodying the present invention; and

Figure 3 shows a pixel arrangement for a display device embodying the present invention.

The television receiver 1 of Figure 1 has a liquid crystal display 2 formed of a lattice of display elements 3 made from liquid crystal material, each element being individually actuatable. The lattice of elements 3 is backlit by a number of fluorescent tubes 4 whose light intensity and duration of operation can be controlled.

The video signal for input to television receiver has a 70Hz scan rate providing a scan period of 14mS, and includes in each picture of display information an 8-bit word for each display element, a word beginning with the most-significant-bit and ending with the least-significant-bit. When this signal is input to receiver 1 via its aerial 5, one picture of display information passes to a frame store 6.

In the processing for the display of the most-significant-bits of the word, frame store 6 outputs the first bit of each word and sends the bits to a control unit 7 for an array of drivers 8, one being assigned to each row and column of the lattice. The driver array sets each element to the condition (on or off) appropriate to its most-significant-bit. Once the array of drivers 8 has set all the elements (which takes less than 1mS), driver control unit 7 instructs light switch unit 9 which checks the rel-

evant bit-position (in this case the most-significant-bit) and then activates the fluorescent tubes 4 for a time duration of 3mS and at an intensity to provide an appropriate output.

When the required output has been achieved then the light switch unit 9 de-activates the tubes 4 and instructs frame store 6 which proceeds to output the secondmost-significant bits to driver control unit 7 thereby to set all the elements for this bit-position. On this occasion, light switch unit 9 activates the tubes half as long as before (namely 1.5mS) at the same intensity to provide only half the output as that for the most-significant bits. This routine is repeated for all eight bits of the words, the light output being halved each time. Once the least significant bit has been displayed (the light output time duration being 25 S), the store 6 is emptied and the next picture of display information is output and the processing described above is repeated.

Figure 2 is a block diagram of a system 10 for displaying off-air video pictures on a bistable display, such as a ferroelectric liquid crystal display panel. Video information is received at aerial 11 and demodulated by the receiver 12; it is then digitized (four bits per pixel) and held in the digital frame store 13.

To display one video frame, firstly the data is split into four streams (one for each bit) and compressed by shift registers 14 so each byte contains data for 8 pixels. The data is then loaded into four buffer RAMs 15, so each RAM now contains one frame of video information 1 bit deep. Accessing of the RAMs 15 and the frame store is done under control of the address generator 16.

For the sequential greyscale processing the data must be sent to the display one bit at a time, i.e. firstly all the data from RAM 0 is sent to the display (the least significant bit), then followed in turn by each of the other 3 RAMs. Also, in order to write data to the light crystal display panel each line of data must be presented in a manner determined by the multiplexing scheme; this processing is performed by the data preparation block 17. Data is now in a form in which it can be sent to the display panel under control of the multiplex controller block 18, each line of data being latched into the column drive chips 19 while rows are strobed by the low drive chips 20. This results in the data being latched into the display. After a full screen of data has been written, the backlight is flashed for a length of time corresponding to the significance of the bit being displayed. This is done by the lamp drive circuit 20 under control of the multiplex controller 18.

The sequence of events which results in a full picture with sixteen grey levels being displayed, is as follows:-

1. Load frame store 13;
2. Load buffer RAMs 15, one significant bit to each;
3. Load data from buffer RAM 0 line into data preparation unit 17;
4. Load data from buffer RAM 1 line by line into data preparation unit 17;
5. Load data from buffer RAM 2 line by line into data preparation unit 17;
6. Load data from buffer RAM 3 line by line into data preparation unit 17;
7. Multiplex controller 18 sends data from preparation unit 17 to column drive chips 119 and controls row drive chips 20;
8. When data from RAM 0 has been latched into the display (i.e. when the least significant bit for the frame is being presented), the multiplex controller 18 signals the lamp drive to flash for a period of time A mS;
9. Data from RAM 1 is now latched and the backlight flashed for 2A mS;
10. Data from RAM 2 is now latched and the backlight flashed for 4A mS;
11. Data from RAM 3 is now latched and the backlight flashed for 8A mS;
12. The picture has now been displayed. Assuming a frame time of 40 mS, then if it takes T mS to set up the display  $4T + 15A = 40$  mS.

Figure 3 shows an arrangement of metallisation patterns for a liquid crystal display panel to achieve a two-bit greyscale, for use additionally or alternatively to the greyscale processing of Figures 1 and 2. On the substrate 30 having the column electrodes, the ITO metallisation patterns are such that each pixel has two sections 31, 32 which can be separately driven from appropriate drive chips (not shown) on flexible pcb boards 33 and 34 via lines 35 and 36 respectively. For each pixel, section 31 corresponds to the least-significant-bit, and section 32 to the most-significant-bit. The row electrodes are formed by ITO metallisation strips 37 on substrate 38, which can be strobed by row drive chips (not shown) on flexible pcb 39 via lines 40. In Figure 3, on the left hand side the substrate has been omitted as indicated by the broken-chain line yet the column metallisation is shown overlying the row metallisation, for the purpose of simplicity.

## Claims

1. A display device comprising:  
a lattice of bi-stable display elements;  
means to input a signal representing the display information for one picture to a store;  
means to output, from the store, the display information for one picture in sections, each section consisting of corresponding portions of display in-

formation for all the bi-stable display elements;  
a plurality of drivers, each allocated to a row or column of the lattice, to set each display element to a condition in accordance with its respective portion of the signal from the output means;  
means to produce a light output; and  
means to modulate the light output in accordance with the significance of the signal from the output means.

2. A display device according to Claim 1, wherein the signal for one picture comprises a sequence of word each one corresponding to the display information for a display element in the lattice, and the output means has means to take out, from the store, the first bit in each word and pass them sequentially to the lattice, and then to take out, from the store, the second bit in each word and pass them sequentially to the lattice, this operation being repeated until all the bits have been so processed.

3. A display device according to Claims 1 or 2, wherein the light modulation means has means to regulate the intensity of the light output in accordance with the given bit-position, and/or means to regulate the duration of the light output in accordance with the given bit-position.

4. A display device according to any one of the preceding Claims, comprising means to blank the elements during setting of the elements for a given bit position.

5. A display device according to any one of the preceding Claims, comprising a lattice formed of groups of three display elements, each of the elements in a group producing a different colour and being set separately.

6. A display device according to any one of the preceding Claims, wherein the lattice is formed of single display elements, each of which is exposed to light of three colours sequentially, an element being re-set after each exposure.

7. A display device according to any one of the preceding Claims, wherein each row and column has an separate driver.

8. A display device according to any one of the preceding claims, wherein a display element comprises a selectively settable liquid crystal cell.

9. A method of operating a grey-scale display having a lattice of bi-stable display elements, the method comprising:-

- inputting a signal, representing the display information for one picture, to a store;
- outputting from the store a section of the display information for one picture, the section consisting of corresponding portions of display information for all the bi-stable display elements;
- using a plurality of drivers, each allocated to a row or column of the lattice, to effect setting of each display element to a condition in accordance with

its respective portion of the signal from the output means;

producing a light output, once the elements are set, modulated in accordance with the significance of the portion of the video signal;

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outputting from the store a second section of the display information, the second section consisting of different corresponding portions of display information for all the bi-stable display elements, and effecting the setting and modulating operations for the second section; and

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repeating the outputting, setting and modulating operations on any further corresponding portions.

10. A method according to Claim 9, wherein the signal comprises an 8-bit word for each element, and the bits, of a predetermined significance, if the words are first output from the store for setting and display, and then thereafter the bits, of another significance, of the words are output from the store for setting and display, the total light outputting being of an appropriate ratio to the previous output, this sequence being repeated until all the bits have been displayed.

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11. A method according to Claim 9 or 10 wherein modulation of the light output is achieved by regulation of the light intensity and/or of the duration of the light output.

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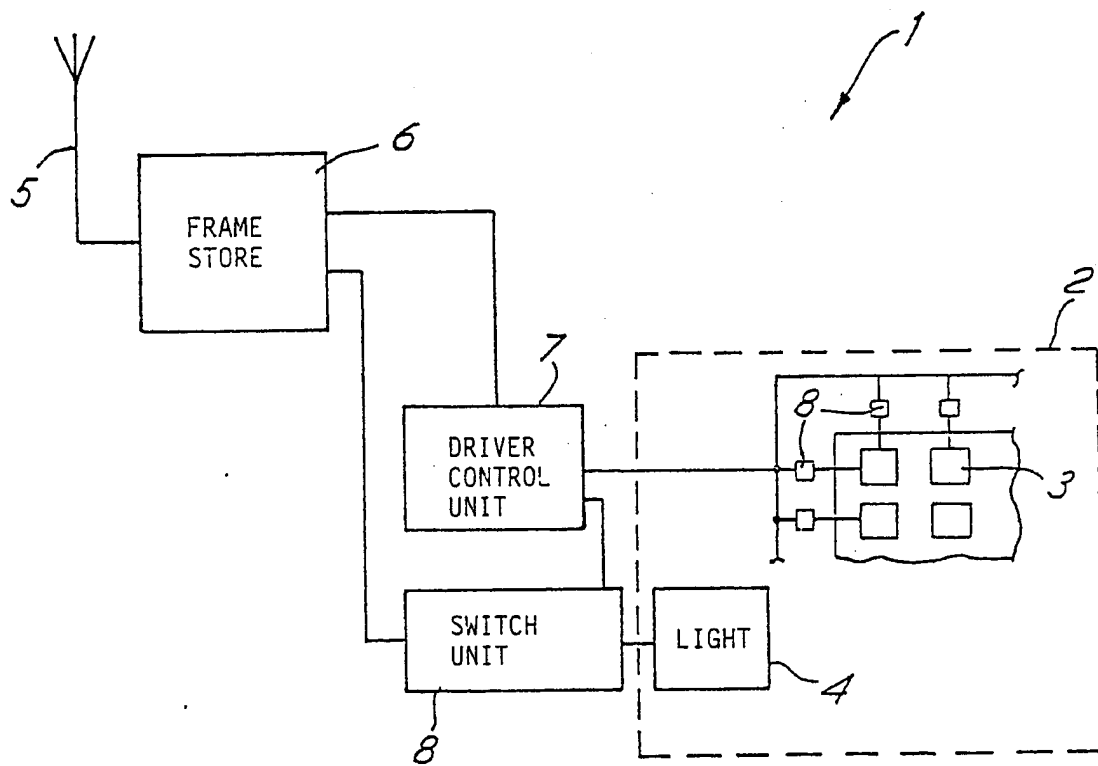


FIG. 1

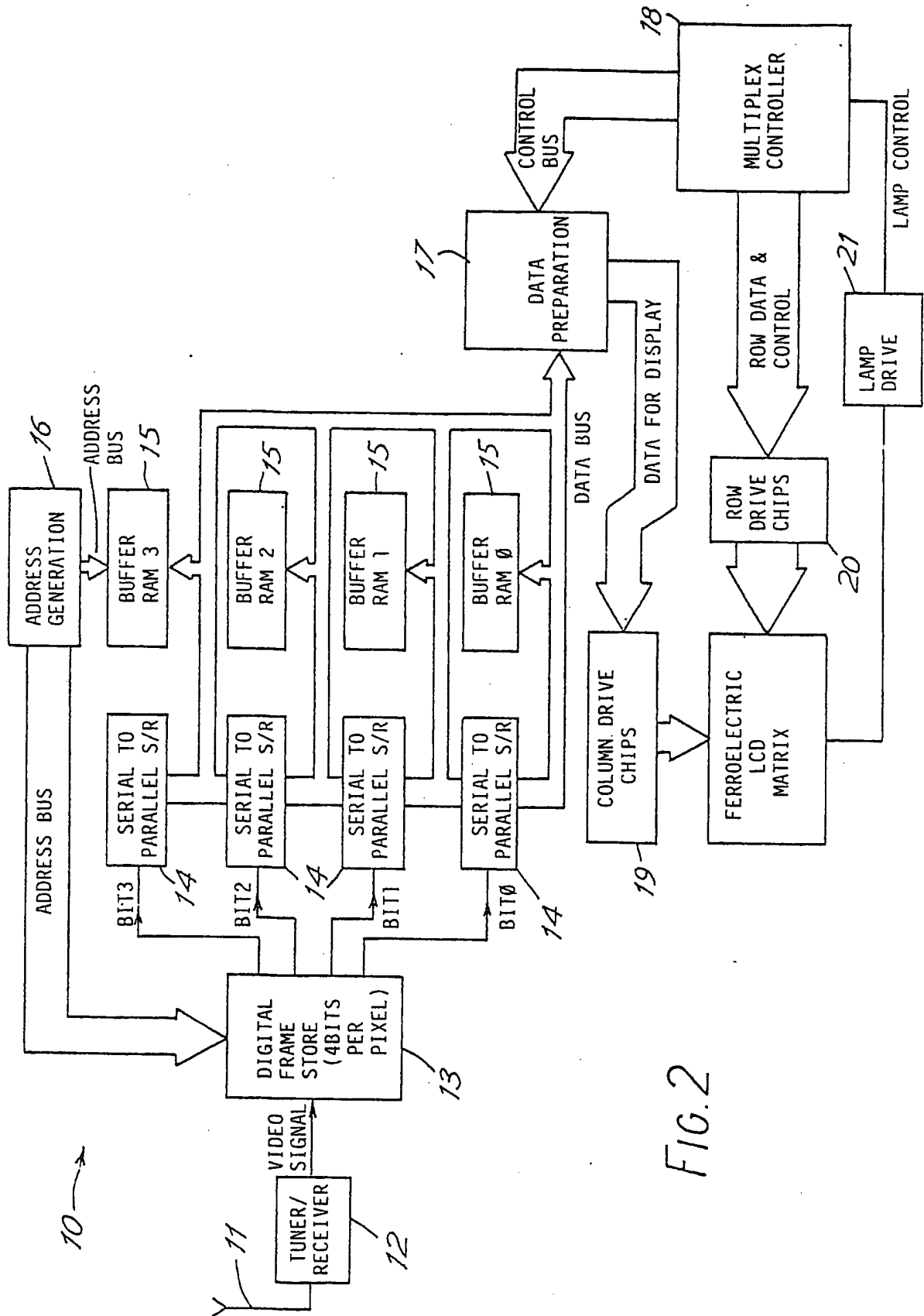


FIG. 2

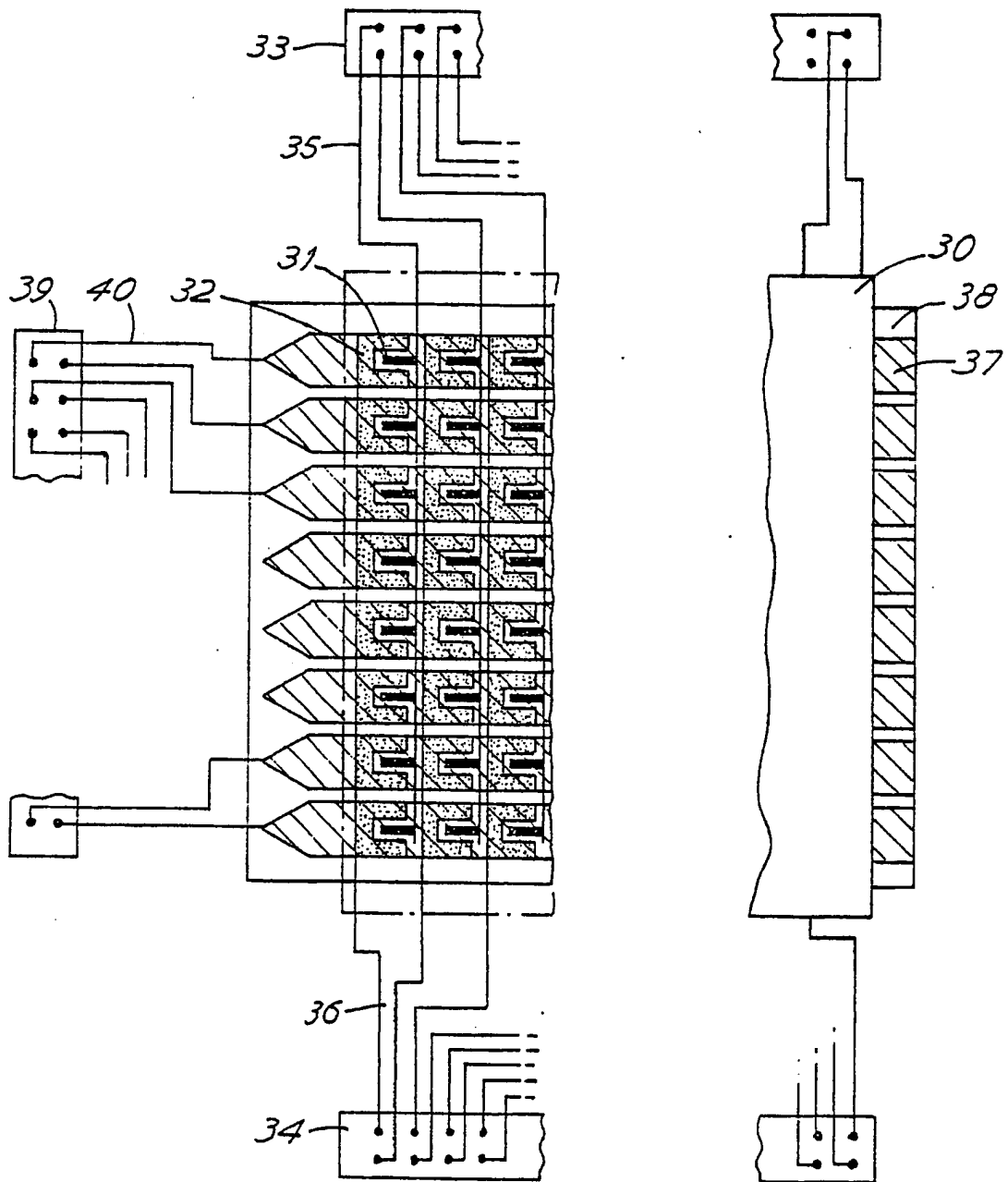


FIG. 3

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